HAI

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Human-Centered
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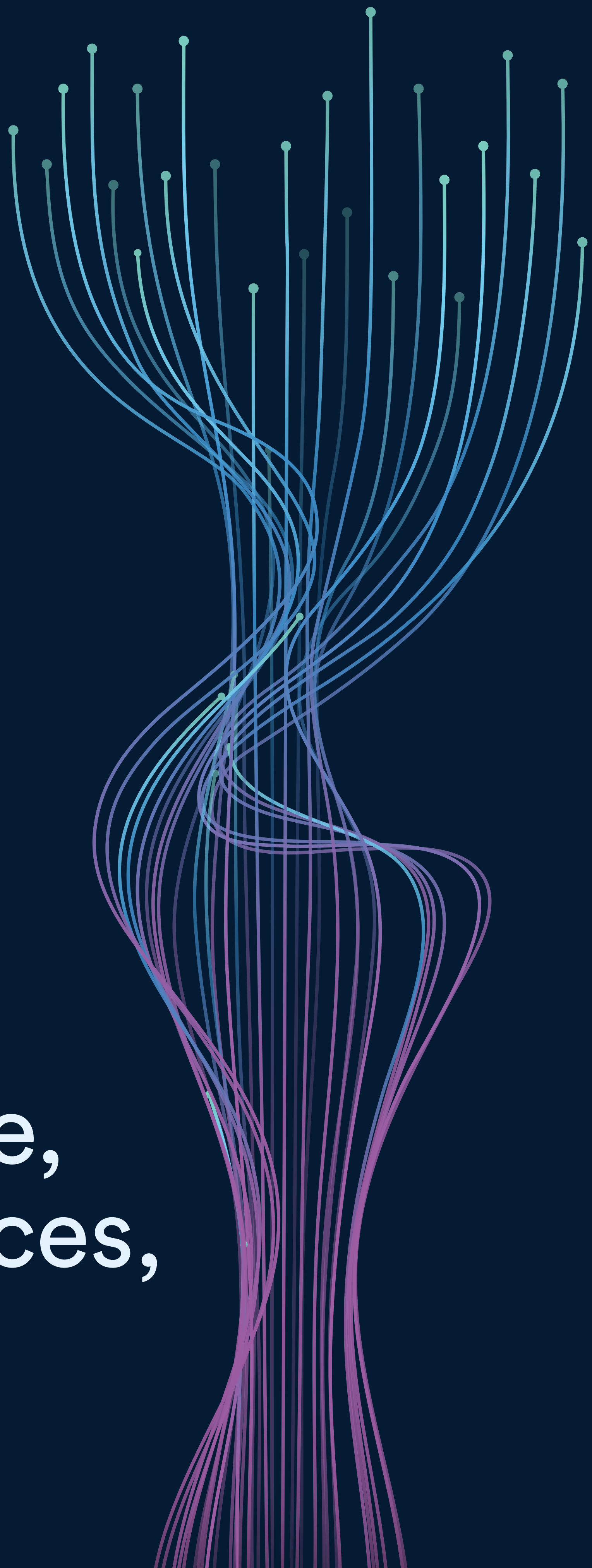

MARCH 2021

INDUSTRY BRIEF

Healthcare, Life Sciences, and AI

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INDUSTRY BRIEF

Introduction

We are pleased to announce our new HAI Industry Briefs, which we hope will provide a valuable bridge between academic research at Stanford and our industry stakeholders seeking to understand and guide the impact of AI technologies.

– John Etchemendy and Fei-Fei Li, the Denning Co-Directors of the Stanford Institute for Human-Centered Artificial Intelligence (HAI)

For the full text of the introduction to the HAI Industry Briefs, visit hai.stanford.edu/blog/announcing-hai-industry-briefs.

HAI's mission is to advance AI research, education, policy and practice to improve the human condition. To learn more about HAI, visit hai.stanford.edu

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INDUSTRY BRIEF

Healthcare & Life Sciences

1 Drug Discovery

2 Telehealth

3 Ambient Intelligence

4 Operational Excellence

5 Medical Imaging

6 Augmented Intelligence

7 Data & Privacy

Photo: Drew Kelly

1 HEALTHCARE & LIFE SCIENCES
DRUG DISCOVERY

WHAT'S NEW?

New computational approaches to drug discovery help to identify and examine relevant protein and molecular targets (such as the COVID-19 spike protein), design candidate drugs, anticipate therapeutic responses and side-effects in patients, and optimize clinical trial enrollment. These approaches leverage natural language processing to extract value from biomedical literature at scale and apply neural network architectures that enable deep learning on multi-modal data and simultaneous predictions on multiple tasks.

WHY DOES THIS MATTER NOW?

Drug development is expensive and time-consuming with low success rates, where it is not uncommon for R&D to cost upwards of $1B and span over 10 years. The COVID-19 pandemic has spurred urgency to accelerate these processes with AI. Indeed, the category "Drugs, Cancer, Molecular, Drug, Discovery" received the greatest amount of AI investment in 2020 with over $13.8B (4.5 times higher than in 2019).

EYE ON CAMPUS

Researchers on campus are...

- Tackling COVID-19 with NLP and machine learning by rapidly scanning biomedical literature for target proteins, predicting the 3D structure of those target proteins, and identifying drug candidates
- Predicting antibody binding sites on the receptor binding domain of the viral spike protein targeted by vaccine development efforts with machine learning
- Predicting antigen molecules relevant to the development of vaccines with multi-modal recurrent neural networks
- Jointly predicting drug response, targets, and side effects with multi-task learning
- Estimating drug side-effect pro-arrhythmia risk by combining machine learning and multiscale modeling
- Optimizing clinical trial enrollment

"By augmenting and enhancing scientist capabilities with computational approaches, AI has demonstrated the potential to overcome major bottlenecks in drug development. In my research with Genentech and Roche, we have found that AI can make clinical trials, one of the lengthiest phases of drug development, both more efficient and more inclusive. This is only an early glimpse into how AI can help us push the boundaries of discovering, testing, and accelerating the delivery of medicines of the future."

–James Zou, Assistant Professor of Biomedical Data Science; HAI Faculty Affiliate

2 HEALTHCARE & LIFE SCIENCES TELEHEALTH

WHAT'S NEW?

Machine learning is being newly applied to digital health contexts to automate processes in virtual patient visits, enable remote clinical diagnoses from patient mobile phone images, and assess the quality of text-based therapeutic services. Reinforcement learning and deep learning on mobile health data additionally enable real-time health analysis and personalized interventions.

WHY DOES THIS MATTER NOW?

COVID-19 has accelerated the adoption of digital health technologies in the form of virtual appointments, chatbots, and wearables -- providers report 50-175 times the number of telehealth visits pre-COVID-19. The additional data generated from these digital touchpoints creates opportunities for AI to enhance remote healthcare delivery and provide more proactive, individualized care.

EYE ON CAMPUS

Researchers on campus are...

- Automating patient history-taking in virtual visits from text with active learning

HAI RESEARCH
- Augmenting psychotherapy in both in-person and digital contexts with NLP

- Identifying diabetic retinopathy with deep learning on mobile phone images
- Detecting poor telehealth image quality for patient guidance with an automated machine learning pipeline
- Detecting stroke risk-factors in real-time from wearable data with multi-task deep learning
- Personalizing mobile health interventions with reinforcement learning
- Detecting illness with "smart toilets" and automated urine and stool analysis

"The landscape of digital health is being rapidly transformed by the COVID-19 pandemic, with the exponential adoption of telehealth and remote care likely to only continue growing in the post-pandemic future. This is an exciting moment to study the possibilities and role of AI in digital health technology."

–Serena Yeung, Assistant Professor of Biomedical Data Science; HAI Faculty Affiliate

3 HEALTHCARE & LIFE SCIENCES
AMBIENT INTELLIGENCE

WHAT'S NEW?

Low-cost sensors and advances in computer vision enable accurate activity recognition in healthcare and daily living spaces where constant human observation is infeasible.

Technical advances in visual tracking, human pose estimation, activity recognition, real-time inference, and generalization to new environments help to overcome major algorithmic challenges to these applications. This progress is reflected by the improving performance of submissions to several computer vision benchmark challenges, such as the ActivityNet Temporal Action Localization Task, which has seen a 140% increase in highest mean average precision in the last five years.

WHY DOES THIS MATTER NOW?

Extended passive vigilance can help improve the quality of healthcare delivery, clinician productivity, and business operations, particularly in times of scarce resources amidst healthcare crises. Fueled by the maturation of computer vision technologies, these solutions are becoming increasingly practical.

EYE ON CAMPUS

Researchers on campus are...

HAI RESEARCH

- Making our hospitals smarter by embedding ambient intelligence into their dark spaces
- Designing integrated solutions to help remotely monitor clinically relevant activities of seniors with non-intrusive sensors

- Measuring movement impairment in patients with cerebral palsy and parkinson's with video
- Monitoring hand hygiene of health workers with depth sensors
- Automating video analysis of surgical operations

"For AI algorithms, understanding dynamic human behavior in health-critical situations is far more challenging than labeling cats and chairs in images. From a technical perspective, many computer vision problems remain to be overcome before these technologies can be widely deployed. However, we are on the right track with researchers and care providers partnering closely to combine the best of sensor hardware, AI algorithms, and a holistic understanding of patient needs and existing practices."

–Fei-Fei Li, Professor of Computer Science and Co-Director of HAI

4 HEALTHCARE & LIFE SCIENCES
OPERATIONAL EXCELLENCE

WHAT'S NEW?

Prediction and simulation tools have been developed in direct response to COVID-19. They have demonstrated potential to effectively allocate limited resources and triage patients in emergency departments and model pandemic spread using population-scale cell phone data.

World class advances leveraging machine learning, mathematical optimization, simulation, and other computational tools show potential to supercharge the engines powering healthcare operations everywhere from hospitals to public health departments.

WHY DOES THIS MATTER NOW?

A health delivery system must be efficient and effective in daily operations but also elastic enough to respond to unplanned systemic shocks. AI has found early success in creating value with automated tools that predict or simulate risk, optimize resource allocation, and enhance operational efficiencies in a system where 25% of spending may already be considered wasteful.

EYE ON CAMPUS

Researchers on campus are...

- Building data platforms that enable AI approaches to clinical data and have already powered insights boosting ICU capacity by 25% at Stanford Hospital
- Developing an AI-based system capable of real-time identification and triage of handwritten faxed COVID-19 forms
- Allocating scarce resources such as COVID-19 PCR tests and PPE according to predicted need
- Informing policy responses with fine-grained simulations of COVID-19 spread as modeled by mobility networks
- Working with the Lucile Packard Children's Hospital Stanford to forecast surgical procedure duration, improve operating room utilization, schedule procedures, forecast patient flow, and automate nurse workload, patient transfer, and billing decision-support

"The insights provided by Stanford Medicine's AI systems on COVID-19 patients have helped front-line doctors reassess the appropriateness of care guidelines and better manage hospital resources without compromising health outcomes. These early successes demonstrate the importance of partnering closely with care providers to bring AI into clinical use, safely, ethically and cost effectively. The challenge after the pandemic will be to make these solutions scalable and sticky to provide lasting value."

–Nigam Shah, Associate Professor of Medicine and Biomedical Data Science; Associate CIO of Data Science @ Stanford Healthcare; HAI Faculty Affiliate

5 HEALTHCARE & LIFE SCIENCES
MEDICAL IMAGING

WHAT'S NEW?

Applications of deep learning to medical images and video continue to show promise in outperforming human experts on a wide range of diagnostic tasks. Researchers also find ways to use less hand-labeled data, reducing costs while still achieving accurate results.

Human-in-the-loop AI outperforms either human or machine alone, suggesting a path to achieving the ideal symbiosis of human experts and AI models.

WHY DOES THIS MATTER NOW?

Hospital systems face pressure to rapidly deliver diagnostic results, while smaller clinics face a shortage of expertise. AI can expand access to advanced imaging and assist physician judgment. AI models can automatically analyze scans not only to enhance clinician accuracy, but also to triage patients according to urgency. Advances in medical imaging analysis may also unlock value beyond immediate clinical questions by enabling longer-range analysis of a patient's imaging history.

EYE ON CAMPUS

Researchers on campus are...

- Automatically extracting labels from radiology text reports using BERT to serve as training data for computer vision experiments.
- Releasing 10,000+ photos of Chest X-rays so clinics can obtain AI advice from smartphones
- Learning medical visual representations from paired images and text, reducing the need for hand-labeled datasets
- Using deep learning on medical images and videos to assess cardiac function, diagnose appendicitis, diagnose pneumonia with swarm-based technology, predict outcomes of non-small-cell lung cancer, and detect pulmonary embolisms

"Progress in deep learning has generated incredible excitement among medical imaging researchers. Because medical images have been captured in standard digital format for decades, scientists are making dramatic progress developing new methods to tackle the massive size and high complexity of medical images. We are starting to see concrete results that improve patient care."

–Curtis Langlotz, Professor of Radiology and of Medicine; Director of the Stanford Center for Artificial Intelligence in Medicine and Imaging Center; HAI Faculty Affiliate

6 HEALTHCARE & LIFE SCIENCES AUGMENTED INTELLIGENCE

WHAT'S NEW?

Machine-learning powered tools show potential to augment decision making systems and provide more personalized care by tapping into existing patient health records and genomic data. Some have moved beyond experimental phases to being deployed in practice, such as Stanford Medicine's first-of-its-kind, in-house whole genome sequencing service, launched in January of 2021.

WHY DOES THIS MATTER NOW?

On top of the estimated $34B - $251B cost of caring for COVID-19 patients, deferred treatments and exacerbated behavioral health problems caused by the pandemic are projected to incur additional costs between $125B and $200B. With employer health insurance premiums expected to rise anywhere between 4% and 40% in 2021 and healthcare spending already accounting for roughly 17% of GDP, urgency to make patient care more efficient and cost-effective with technology should not be felt by healthcare providers alone. AI tools have the potential to scale care without sacrificing cost, quality, and access.

EYE ON CAMPUS

Researchers on campus are...

- Launching the first in-house clinical, whole-genome, sequencing-based diagnostic testing service, initially targeting patients with inherited cardiovascular diseases
- Predicting the deterioration of patients with COVID-19 from past respiratory infection data
- Informing advanced care planning by predicting 12-month mortality from EHR data
- Distinguishing high-value from low-value medical diagnostic testing with a systematic machine learning approach

HAI RESEARCH

- Mining patient electronic medical records to assess and recommend clinical orders, inspired in approach by Amazon's and Netflix's product recommenders*

- Predicting patient response to antidepressants and antibiotic susceptibility with machine learning

* Only first reference is to HAI funded research.

"As offline AI algorithms in healthcare improve, we are increasingly turning to the challenges of real time implementation. It is an urgent priority to understand how human experts respond to a workflow augmented by AI and to study how AI is, in turn, incrementally impacted by expert input or new observations. Indeed, completing the Human Intelligence-Artificial Intelligence cycle will be the major focus for healthcare AI efforts over the next few years."

–Euan Ashley, Professor of Medicine & Genetics; Associate Dean, Precision Health

7 HEALTHCARE & LIFE SCIENCES DATA: BIAS & PRIVACY

WHAT'S NEW?

Researchers have developed new computational and ethical frameworks for identifying and addressing issues of bias, consent, security, privacy, and justice. Techniques such as federated learning and secure multi-party computation (SMC) demonstrate potential as privacy-preserving approaches to aggregating, sharing, and computing on data for machine learning while maintaining regulatory compliance and patient privacy.

WHY DOES THIS MATTER NOW?

During COVID-19, AI has already shown potential to exacerbate health disparities and inspired calls for industry to create better off-the-shelf technologies for protecting patient privacy while responding to the pandemic. As medical AI becomes more widely deployed, both developers and health practitioners must ensure the technology and its applications benefit the entire population.

EYE ON CAMPUS

Researchers on campus are...

- Deploying the world's largest application of SMC in a health context, demonstrating the practicality of privacy-preserving analytics for population-scale digital health interventions
- Developing a federated learning-based distributed AI system for detecting COVID-19 without sharing patient data across institutions
- Identifying geographic bias in datasets used to train clinical deep learning algorithms
- Raising concerns about unrepresentative training data and a lack of regulated COVID-19 data resources that may be exacerbating disparities or underrepresenting older people and people of color

HAI RESEARCH

- Developing ethical frameworks for the sharing and use of clinical and sensor data in AI development*

* Only second reference is to HAI funded research.

"As biomedical AI increasingly moves into real-world use, we must ensure that it is a force for addressing health disparities, not exacerbating them. It is imperative that all stakeholders - academia, industry, regulators, clinicians, patients, ethicists, and others - proactively collaborate to anticipate and address these issues."

–Russ Altman, Professor of Bioengineering, Genetics, Medicine, and Biomedical Data Science; Associate Director of HAI

Industry Take

Industry will play a critical role in scaling the applications of AI research. For this reason, it is a goal and privilege of HAI to convene stakeholders from industry in addition to those in academia, government, and civil society to address the technical and societal challenges posed by AI.

Leading venture investors, positioned at the frontlines of startup innovation, can provide a unique perspective on the development and deployment of AI technologies in the healthcare and life sciences industries.

Industry Take

"In recent years the power of AI to augment human performance to superhuman levels has been amply demonstrated in diverse medical applications such as interpreting radiological images, histopathology, genomics, colonoscopies, retinal images, EKGs, identifying gaps in care, and providing improved antibiotic recommendations. There should now be no question that AI, if deployed correctly, can be used to increase the quality of care, lower costs, and increase accessibility. Radical new technology can create opportunities for radically new ways of providing healthcare and new business models."
–Alex Morgan, Partner, Khosla Ventures

"With a growing shortage of physicians and the increased strain caused by the pandemic, many medical professionals have their schedules packed so tightly that much of the human element which motivated their pursuit of medicine in the first place is reduced. In this state of affairs, AI will be an accelerant and enabler, not a threat. Already, it is helping care providers scale their ability to proactively detect and mitigate the risk of adverse events. Automated scribes are reducing the burden of tedious tasks, allowing doctors to focus on the patient. It would be good business for AI companies to help, rather than attempt to replace, medical professionals."
–Konstantin Buhler, Partner, Sequoia Capital

"Given its immense potential utility, AI is now a part of every link on bio's value chain, from drug discovery, to diagnostic development, to healthcare delivery technologies. There are so many new applications for AI in bio that it is increasingly difficult to delineate the signal from the noise. One of the best ways to do this is to determine whether a new AI-driven technology is differentiated from the competition. To understand the innovative nature of a given product, it is naturally important to have a deeper understanding of the application domain (medical transcription, drug design, biomarker discovery, clinical trial prediction, etc). The core question here is whether it actually enables something unprecedented in the field, be it a completely new use case or an order of magnitude improvement in speed/efficiency/cost/etc. The logic here is actually the same for all new products, AI or not."
–Vijay Pande, General Partner, Andreessen Horowitz
Adjunct Professor of Bioengineering, Stanford University

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LATEST FROM HAI FACULTY

Nearly 200 Stanford faculty are affiliates of Stanford HAI, spanning all **seven schools** and more than **90 departments.**

The Value of Data and AI: Strategies for Senior Leadership, is an upcoming HAI Executive Education Program in which Stanford faculty take senior executives and key decision-makers through the emerging business strategies and research around the economics of data and AI.

Program: March 29 - 31

Application Deadline: March 22

Apply early for the best chance to secure your seat. Admitted applicants should use the promo code “**INDUSTRYBRIEF**" at the time of course registration to receive a **20% discount** for the program.

Submit your application today.

JAMES ZOU

is the HAI Faculty Director for The Value of Data and AI Executive Education Program. He is an Assistant Professor of Biomedical Data Science (and Computer Science and Electrical Engineering, by courtesy), HAI Faculty Affiliate, Faculty Director of Stanford AI for Health, and a Chan-Zuckerberg Investigator.

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Are you prepared for the next wave of change?

THINGS YOU SHOULD KNOW.

52%

of Fortune 500 companies were extinguished by digital disruption between 2000 and 2014[1]

$15.7T

in value will be added by AI to the global economy by 2030[3]

50%

of the S&P 500 in 2018 was forecasted to be replaced in just ten years[2]

$1.4B

in annualized value can be gained by AI-led transformation of a Fortune 500 company[4]

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2 Scott D. Anthony et al., "2018 Corporate Longevity Forecast: Creative Destruction is Accelerating," *Innosight*, February 2018.
3 "PwC's Global Artificial Intelligence Study: Sizing the prize," *PricewaterhouseCoopers*, Retrieved March 1, 2021.
4 "Incorporate enterprise A.I. now or risk getting disrupted," *Fortune + C3*. Ai, Retrieved March 1, 2021.

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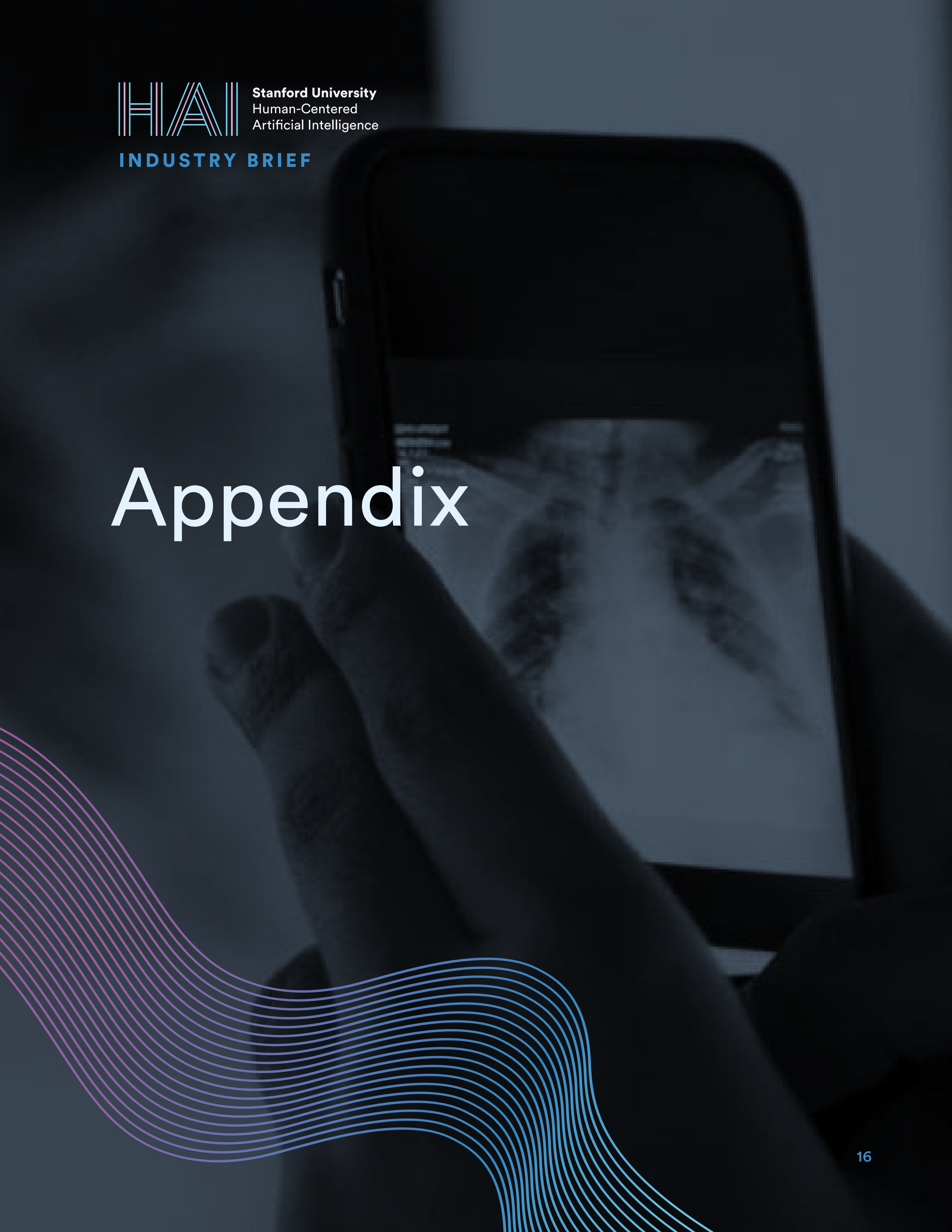
Become a corporate member today.

50% of companies are likely to miss the window of opportunity.[1] Let's talk.

Learn more about the Corporate Members Program and the Stanford advantage.

Panos Madamopoulos,
HAI Director of Partnerships

1 Jacques Bughin, "Wait-and-See Could Be a Costly AI Strategy," *MIT Sloan Management Review*, June 15, 2018.



Appendix

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Artificial Intelligence Definitions

Intelligence might be defined as the ability to learn and perform suitable techniques to solve problems and achieve goals, appropriate to the context in an uncertain, ever-varying world. A fully pre-programmed factory robot is flexible, accurate, and consistent but not intelligent.

Artificial Intelligence (AI), a term coined by emeritus Stanford Professor John McCarthy in 1955, was defined by him as "the science and engineering of making intelligent machines". Much research has humans program software agents to behave in a clever way, like playing chess, but, today, we emphasize agents that can learn, as human beings navigating our changing world do.

Autonomous systems can independently plan and decide sequences of steps to achieve a specified goal without micro-management. A hospital delivery robot must autonomously navigate busy corridors to succeed in its task. In AI, autonomy doesn't have the sense of being self-governing that is common in politics or biology.

Machine Learning (ML) is the part of AI studying how computer systems can improve their perception, knowledge, decisions, or actions based on experience or data. For this, ML draws from computer science, statistics, psychology, neuroscience, economics, and control theory.

In **supervised learning**, a computer learns to predict human-given labels, such as dog breed based on labeled dog pictures; **unsupervised learning** does not require labels, sometimes making its own prediction tasks such as trying to predict each successive word in a sentence; **reinforcement learning** lets an agent learn action sequences that optimize its total rewards, such as winning games, without explicit examples of good techniques, enabling autonomy.

Deep Learning is the use of large multi-layer **(artificial) neural networks** that compute with continuous (real number) representations, a little like the hierarchically-organized neurons in human brains. It is currently the most successful ML approach, usable for all types of ML, with better generalization from small data and better scaling to big data and compute budgets.

An **algorithm** lists the precise steps to take, such as a person writes in a computer program. AI systems contain algorithms, but often just for a few parts like a learning or reward calculation method. Much of their behavior emerges via learning from data or experience, which is a sea change in system design that Stanford alumnus Andrej Karpathy dubbed **Software 2.0**.

Narrow AI is intelligent systems for particular tasks, e.g., **speech** or **facial recognition**. **Human-level AI**, or **Artificial General Intelligence (AGI)**, seeks broadly intelligent, context-aware machines. It is needed for effective, adaptable **social chatbots** or **human-robot interaction**.

Human-Centered Artificial Intelligence is AI that seeks to augment the abilities of, address the societal needs of, and draw inspiration from human beings. It researches and builds effective partners and tools for people, such as a robot helper and companion for the elderly.

Text by Professor Christopher Manning, v 1.1, November 2020

Learn more at hai.stanford.edu

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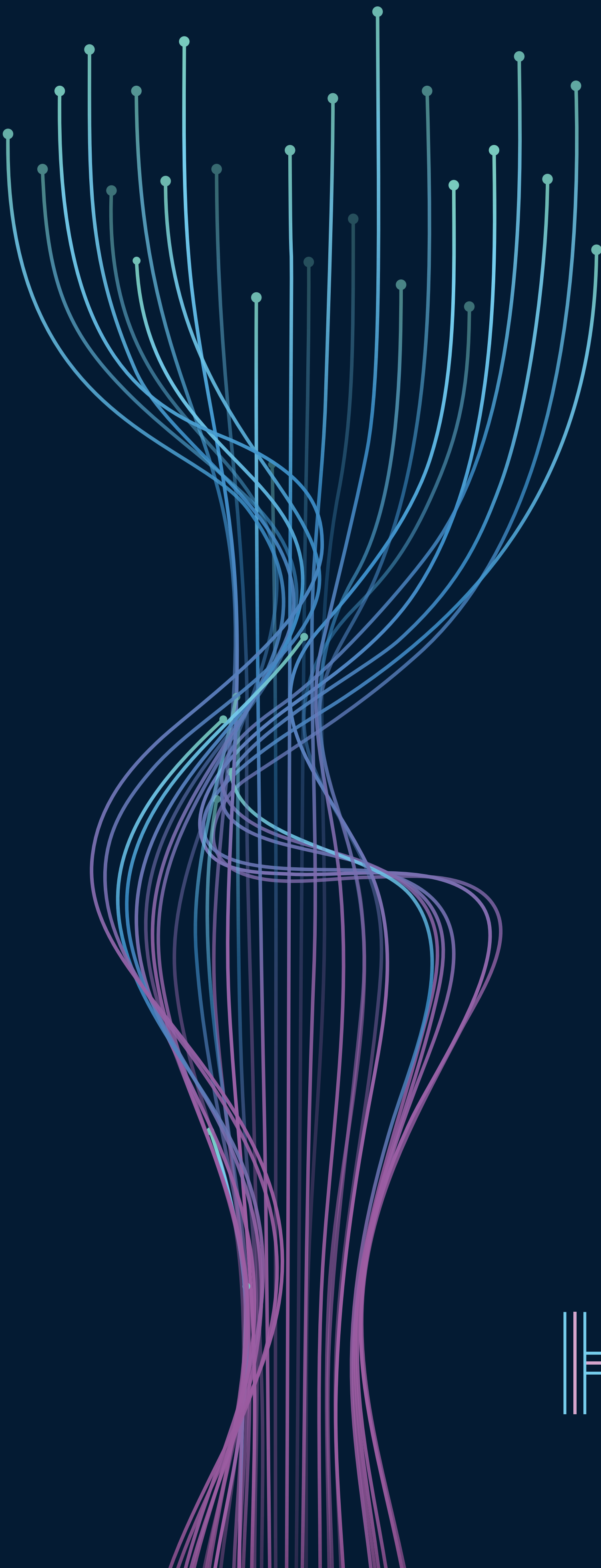

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